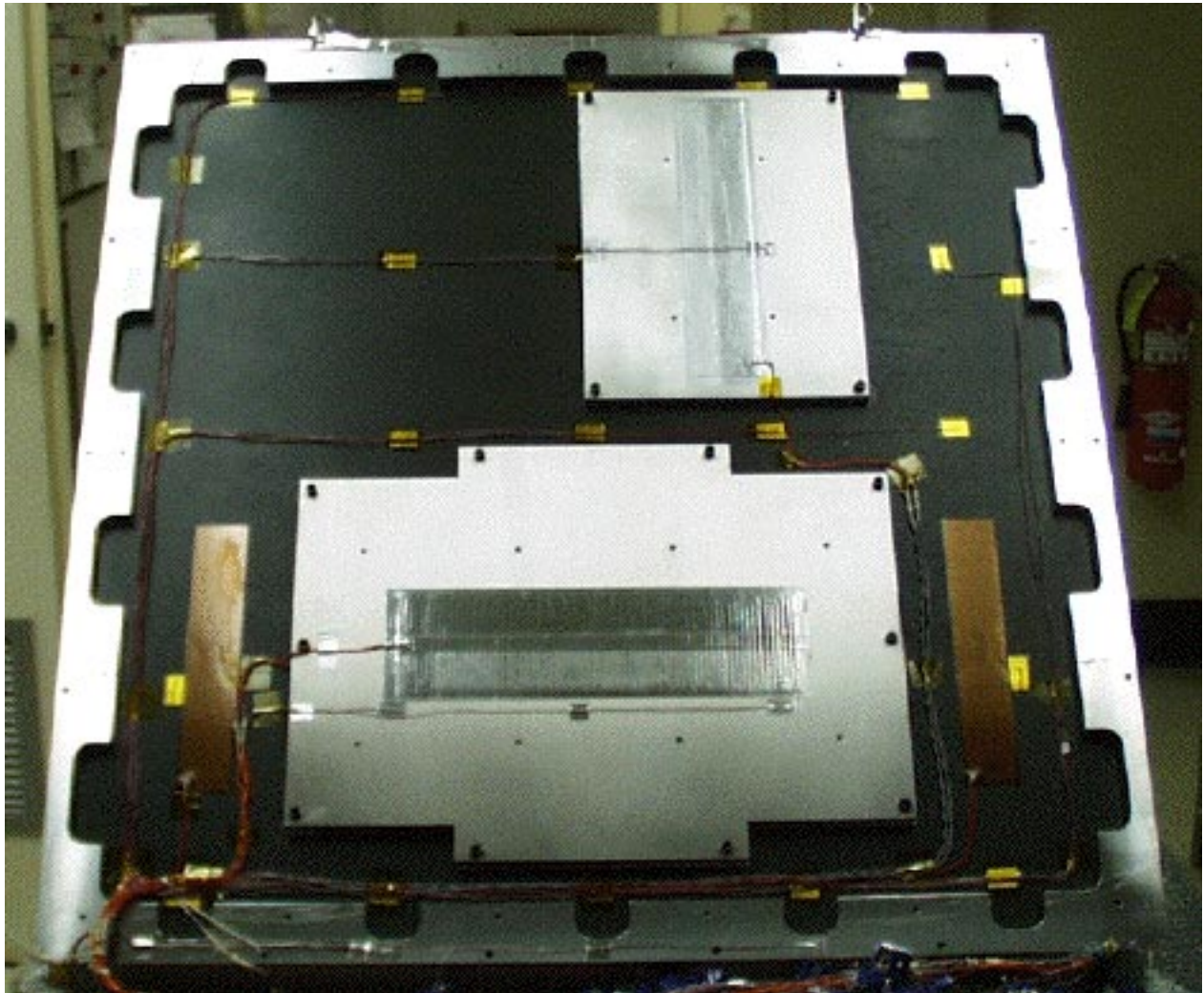


CARBON-CARBON COMPOSITE RADIATOR PANEL IMPROVES THERMAL CONTROL ON SATELLITES

Accomplishment: An informal partnership has been established to promote the use of carbon-carbon on spacecraft, called the Carbon - Carbon Spacecraft Radiator Partnership (CSRP). CSRP membership includes research engineers and scientists at the Air Force Research Laboratory's Materials and Manufacturing Directorate and Space Vehicles Directorate, the Naval Surface Warfare Center's Carderock division, NASA's Langley Research Center, NASA's Goddard Space Flight Center and private industry (TRW, Lockheed Martin Astronautics, Lockheed Martin Missiles & Space, Lockheed Martin Vought, Amoco Polymers, Materials Research & Design, and BF Goodrich) . The CSRP has designed and fabricated a revolutionary radiator panel that could significantly reduce thermal control costs associated with satellites and possibly extend their operational lives. Their new carbon-carbon panel will be integrated on the "Earth Orbiter 1" spacecraft to be launched in December, 1999. The panel was built to demonstrate that carbon-carbon can be a cost efficient choice for radiators and the panel will be instrumented for on-orbit data. If successful, the new panel may dramatically change how radiators are constructed for future spacecraft and could lead to other important cost- reduction applications in space and private industry.

Background: Satellites in orbit around the Earth must dissipate tremendous amounts of waste heat from absorbed solar radiation and internal heat sources. The primary way to disperse thermal energy is through a series of special radiator panels affixed to the outside of the spacecraft. The current Earth Orbiter 1 spacecraft program uses passive radiators consisting of honeycomb core with aluminum facesheets to cool the spacecraft. These panels perform well but researchers would like to enhance the thermal management capability even further by reducing the costs and weight and possibly extending the operational life of the spacecraft. The CSRP has replaced one of the satellite's honeycomb aluminum radiator panels, measuring about 28 by 29 inches, with an experimental C-C panel. The new C-C panel will be used in an area where high thermal conductivity is needed to meet the thermal requirements. Flight and spare panels were built and both were subjected to flight qualification testing. Carbon-carbon is a very special class of composite materials in which both the reinforcing fibers and matrix materials are made of pure carbon. The use of high conductivity fibers in C-C fabrication yields composite materials that have high stiffness and high thermal conductivity and, since C-C density is considerably lower than that of aluminum, significant weight savings can be realized by replacing aluminum panels with such panels. C-C also has an advantage over other high conductivity composite materials in that the thermal conductivity through the thickness is considerably higher. The trend for future satellites is towards higher power density in combination with a reduction in spacecraft size and weight. Since C-C materials also have a markedly higher specific thermal efficiency than aluminum; they offer improved performance for lower volume and mass. They will enable more compact packaging of electronic devices because of their ability to effectively dissipate heat from high power density electronics. Studies have shown that entire heat pipe panels may be replaced by high conductivity C-C for some applications, thus reducing system complexity as well as integration and testing costs. Also, since carbon-carbon is a structural material, it serves a dual purpose

as both a structural and thermal management material that will eventually eliminate the requirement for thermal doubler plates, which typically add substantial mass to a spacecraft. Finally, because C-C is a composite, its structural and thermal properties are tailorable, thus adding capability and flexibility to spacecraft designs. The new C-C radiator panel is one of eight technologies that will be demonstrated on the Earth Orbiter 1 satellite, to be launched under NASA's "New Millennium Program."



The Carbon-Carbon Radiator is shown instrumented for thermal vacuum testing and in a support frame. The two heater plates representing the electronics boxes and the survival heaters are attached to the backside (or inside) of the radiator. The LEISA plate is in the upper right, the PSE plate is in the lower center, and the two survival heaters are on both sides of the PSE plate. Also shown are the two plate heaters and the thermocouples that were used to monitor the temperature of the radiator during testing. The other side of the radiator is covered with silver teflon tape and will be exposed to space during the flight.

Payoff: The carbon-carbon radiator panel conducts thermal energy more efficiently than other materials currently being used to dissipate thermal energy on satellites. The use of high conductivity fibers in C-C fabrication yields materials that have high stiffness and high thermal conductivity, and since the density of C-C panels is considerably lower than aluminum panels typically used on satellites, significant weight savings can be realized by replacing Aluminum radiators with C-C radiators. C-C also has an advantage over other high conductivity composites materials in that the thermal conductivity through the thickness of the material is significantly higher. C-C also has markedly higher specific thermal efficiency than aluminum and offers improved performance for lower volume and mass.



Representatives from the CSRP with one of the C-C panels. From left to right: Bradford Parker (NASA/GSFC), Suraj Rawal (LM-AD), Joe Wright (LM-V), Dan Butler (NASA/GSFC), Eric Becker (AFRL/MLBC), Brian Sullivan (MR&D), Wallace Vaughn (NASA/LaRC), Elizabeth Shinn (AFRL/MLBC), Howard Maahs (NASA/LaRC), Al Bertram (NSWCCD) and Steve Benner (NASA/GSFC). Not present: Ed Silverman (TRW), Jim Findley and Andy Klavins (LM-M&S), Chris Sprague (Amoco), Wei Shih (BF Goodrich), Waylon Gammill, Don Gluck and Charlotte Gerhart (AFRL/VSVT)

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